Enhanced Technique To Improve The Performance of Genetic Algorithm

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INTRODUCTION

Many researchers (Tucker 2007, Dong 2006) proposed several techniques to solve constraint optimization problems. Some extra tuning functions are implemented in many of the methodologies for the infeasible solutions in the initial search space. These tuning functions are in different forms for different problems and it is identified that a special form of tuning function is necessary for an optimal convergence in GA.

Tuning the optimal convergence of GA is a difficult task in most of the real world problems. Many researchers handled constraints at the chromosome level to differentiate the best and worst individuals from the initial search space. But genes have the deciding authority to produce offspring with new genetic traits. Here tuning is done at the interior part of the chromosome i.e., tuning is done at genes (alleles) in chromosomes is called Gene Inactivation (GI).

If the tuning is done at gene level, worst chromosomes have the chance to make them better in the population. Gene Inactivation is one such tuning method in which the important attributes are identified and inactivated (preserved) throughout the genetic process.

Biological Ammunition:

The Basic unit of all the living organisms is cells. For their most basic necessities they share this basic machinery. Collection of proteins forms the DNA molecules, which is relatively very large. Each protein has its own specifications in the molecule. Hence the DNA sequences are separated into mRNA molecules, with each transcript coding for different molecule. Hence, Gene is the segment (locus) formed from a DNA molecule.

All the genes are combined to form chromosomes. Each gene in the chromosome is responsible for specific function. The expression of the individual genes are organised and disallows manufacturing its entire collection of proteins. The cells organize the rate of translation and transcription of different proteins individually. Hence among the entire collection of genes not all the genes are active at an instance, some of the genes are inactive i.e., they are prevented in doing their regular work of protein synthesis.

For example, some of the genes remain active only at the period of embryogenesis they are inactivated in healthy adults. Likewise, certain genes have to be activated in certain parts of the body and some should be inactivated when the function of the gene is not required. Some of the genes induce the hair to grow in skins they are activated in skin and they are inactive in remaining parts of the body like brain, tongue etc.

Inactivating the gene is heritable, i.e., when a gene in a chromosome is inactivated and during crossover, when offspring are produced they not only copies the DNA, but also they holds the concept of inactivation.

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Many researches had done research on genetics and enough knowledge is obtained on gene inactivation. The concept can be implemented in many research areas. For example, by inactivating the gene new cancer therapies can be produced. Determination of gene function can also be done by inactivating the genes.

**Gene Inactivation:**

The basic concept of GA follows the principles of natural evolution. Gene Inactivation concept can be implemented in the Genetic Algorithm like other natural genetic operators like crossover and mutation. Like other biologically inspired operators transformation of genes (Simoes et al. 2001) and transposons (Simoes et al. 2003) etc., gene inactivation can also be implemented in Genetic Algorithm to produce better result.

The collection of chromosomes or individuals forms initial population for the genetic process. Each chromosome is further divided into genes, which is the final target for our proposed approach Gene Inactivation (GI). The approach is applicable in the problems where user defined constraints to be fixed or to fix the preferences in a particular problem apart from the optimization criteria.

The approach works only at the gene level. The genes which are applicable to the user preferences are inactivated, i.e., the inactivated genes are not involved in any genetic operations like crossover and mutation. Generally during crossover, it affects the genes which are useful to produce good solutions. Since the proposed approach heritable, the identified genes are preserved during the crossover and mutation operations. With this the entire chromosomes are carried over to the successive generations till the optimal solution is obtained. Since the chromosomes perform normal crossover and mutation operations, the application of gene inactivation to a particular gene will not necessarily lead the Genetic Algorithm to the false solution.

**Gene Representation:**

Let C1 and C2 be the chromosomes. The entire sets of genes present in the chromosomes are shown in the Figure 1:

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>G11</td>
<td>G21</td>
</tr>
<tr>
<td>G12</td>
<td>G22</td>
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<td>G13</td>
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<td>G17</td>
<td>G27</td>
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<td>G18</td>
<td>G28</td>
</tr>
<tr>
<td>G19</td>
<td>G29</td>
</tr>
</tbody>
</table>

**Fig. 1:** Representation of chromosomes during gene inactivation

In the chromosome C1, the gene in the position 7 is inactivated. Hence the gene G17 will not participate in crossover or mutation operations.

**Gene Inactivation during Crossover:**

As a result of GI, it is very much evident during the process of crossover and mutation over successive generations. Being heritable in nature, the inactivation gene does not take part in the process of crossover and mutation. Let C1 and C2 be the chromosomes and the gene G17 is inactivated as shown in Figure 2. Assume single point crossover takes place between the chromosomes and the cut point is chosen at random position in the chromosomes.

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>G11</td>
<td>G12</td>
</tr>
</tbody>
</table>

**Fig. 2:** Effect of gene inactivation during crossover

Figure 6.2 implies that the genes in the chromosomes C1 and C2 get exchanged after the cut point. The gene G17 in chromosome C1 was not exchanged due to inactivation based on instance preference.
If the object preference lies before the crossover point, single point crossover and two point crossover does not have much effect during gene inactivation. But when uniform crossover is applied it will have impact on gene inactivation. Since gene inactivation is heritable in nature the setup remains unaffected in successive generations.

**Methodology of Gene Inactivation:**

During Gene Inactivation the required genes are not strictly set in the initial search space. The individuals are allowed to develop naturally and whenever the chromosomes are involved with the user preference they are inactivated immediately. As GI is heritable, the setup remains unchanged throughout the successive generations.

The pseudo code for the proposed method Gene Inactivation is as follows:

1. **[ Initialization ]**
   Generate the initial population by random.

2. **[ Gene Inactivation ]**
   Inactivate the genes in each chromosome based on the preference.

3. **[Fitness Evaluation ]**
   Calculate the fitness value of each individual in the population.

4. **[ Breeding ]**
   - Select the parents from the population using selection mechanisms.
   - Mate the parents to produce new offsprings.
   - Mutate the new offsprings.
   - Calculate the fitness of offspring.
   - Replace the offspring.

5. **[ Termination ]**
   Repeat the process from step -3 till the termination condition is reached.
   Select the best solution from the current population.

Here, the initial populations are generated by random. As the population evolves, the genes that match the criteria with the user preference in each individual get inactivated. This setup remains unchanged throughout the execution. Let the initial population in the search space be as shown in the Figure 3.

![Fig. 3: Initial populations for gene inactivation](image)

Let the preferred genes be in the fourth and the seventh position of the chromosome. Scan the entire population to see if the gene partitioning to the preference vector positions by the user is satisfied. If it is satisfied, the corresponding gene is inactivated. Here, the shaded positions are the gene which satisfies the preference vector. Hence the genes are inactivated.

After inactivation usual genetic operators are applied to the individuals. During crossover and mutation the inactivated genes are not affected and also the new gene positions in other individuals may obtain the preferred values. Once the genes are inactivated, they remain unaffected throughout the genetic process. Thus the evolution is completed without any change.

**Performance Analysis:**

The required best solutions are not identified by the standard Genetic Algorithm in expected time period. Hence the proposed method is implemented in SGA to satisfy the required object preferences. To analyse the performance of GI, the method is applied for 0/1 knapsack problem and the comparison is made with SGA. With the influence of various parameters, a detail study is made on GI to analyse the performance.

- Impact of Population Size
- Impact of Selection Mechanism – Tournament Selection
• Impact of Different Crossover methods
  • Single Point Crossover
  • Two Point Crossover
  • Uniform Crossover
• Impact of Different Crossover Rates
• Impact of Mutation
• Impact of Different Mutation Rates

**Impact of Population Size:**
Population plays a vital role in analysing the performance of the algorithm. Comparison of SGA and GI is done with different population sizes. The results of both the methods for varying population sizes are compared by taking the population sizes as 100 and 200. The Figures 4 to Figure 7 shows the profit and convergence obtained for varying population sizes.

![Fig. 4: Profit obtained on population size 100](image)

![Fig. 5: Convergence obtained on population size 100](image)

![Fig. 6: Profit obtained on population size 200](image)
Impact of Selection Mechanism:

The previous experimental results based on selection mechanism shows that Tournament Selection produces the optimal result compared to Roulette Wheel Selection and Rank Based Selection method. Hence the proposed approach is implemented only on Tournament Selection mechanism. The results are compared with SGA with the same parameter set.

Figure 8 and Figure 9 shows the profit and convergence obtained when Tournament Selection mechanism is applied on SGA and the proposed Gene Inactivation method.
Impact of Different Crossover:

As the proposed method Gene Inactivation method targets at genes in chromosomes, the effect of the proposed method is very much felt during crossover and mutation operators. Hence different crossovers are applied in the proposed method and the performance is compared with SGA.

Fig. 10: Profit obtained on single point crossover

Fig. 11: Convergence obtained on single point crossover

Two point crossover means two crossover points are made to form recombination operation. The figures show the comparison of SGA over GI when two point crossover applied on both the methods with the common parameter set. The figure shows that GI converges faster than SGA.

Fig. 12: Profit obtained on two point crossover
When uniform crossover is applied, the impact differs compared to single point and two point crossover. Figures 14 to 15 show the impact of the uniform crossover on profit and convergence respectively.

**Impact of Crossover Rate:**

Generally the crossover rate varies from 0.80 to 0.95, to make all the individuals to take part in the genetic process. Hence different crossover rates are studied and the values obtained.
Fig. 16: Profit obtained at crossover rate=0.85

Fig. 17: Convergence obtained at crossover rate=0.85

From Figures 16 and 17 it is inferred that GI converges maximum profit compared to SGA when crossover rate (Cr) is 0.85. Similarly the crossover rate (Cr) at 0.90 is applied to both the approaches with the standard parameter sets.

Fig. 18: Profit obtained at crossover rate=0.90
Fig. 19: Convergence obtained at crossover rate=0.90

From Figure 18 and 19 it is inferred that at Cr=0.90, the proposed GI method converges faster compared to SGA. And also GI produces good profit than SGA. With the common parameter sets, both the methods are applied at the crossover rate (Cr) 0.95. Figure 20 illustrates the profit obtained by both the methods at Cr=0.95 and similarly Figure 21 shows the convergence obtained when crossover rate Cr is at 0.95.

Fig. 20: Profit obtained at crossover rate=0.95

Fig. 21: Convergence obtained at crossover rate=0.95

With the different crossover rates the proposed method GI works better both in terms of profit and convergence.
Impact of Mutation Rate:
Mutation has less chance to participate in Gene Inactivation. Hence the optimal Mr is alone considered to
analysis the performance of both GI and SGA. The optimal mutation rate considered here is 0.20, in previous
experiments Mr=0.20 produces good individuals compared to other mutation rates. Figure 22 shows the profit
obtained and Figure 23 shows the convergence obtained during several executions.

![Figure 22: Profit obtained during mutation](image)

From the figure it is inferred that GI produces best population in short period of time than SGA.

![Figure 23: Convergence obtained during mutation](image)

Conclusion:
The paper has brought the problems associated with constraints using GA by inactivating the genes based
on user preferences. Gene Inactivation was tried and experimented for various numbers of populations. As the
crossover operator is the major prejudicial component after inactivating the particular gene, the impact of gene
inactivation over many crossovers were tried and finally the best crossover to be used with gene inactivation
was identified. Also, it is observed that the application of the gene inactivation in genetic algorithm does not
result in any local stagnation or population diversity (premature convergence) which would be seen from the
graphs and the profits achieved for several executions of the algorithm.

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